Combined RHESSI & Hinode(XRT) (Micro)Flare Observations

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Outline & Motivation

• Investigate particle heating and acceleration in active region microflares (small A,B-Class flares) via X-ray observations
  – RHESSI and Hinode/XRT
• Detailed analysis in a few events (with multi-wavelength) leading to statistical survey of many events
  – Insights into the “standard model”
  – Many microflares to work with
• Details of previous combined observations
  – But degraded performance with pre-anneal RHESSI
• New Microflare Observations
  – December 2007 microflares from AR10978
  – Post-anneal RHESSI
Flare Standard Model: X-ray Perspective

• Aspects of Standard Model
  – Energy Release
  – Energy Transport
  – Emission Mechanism

• Need not be separate or independent processes

• RHESSI provides information about the accelerated particles & high temperature emission

• XRT provides information about the dynamical thermal response to these particles.
Hinode/XRT

- Direct soft X-ray imaging, with high sensitivity & resolution
- Dynamics and thermal response to accelerated particles

- **Challenges: Can be saturated during the bright impulsive phase**
  - Issue for microflares, far worse for M/X-class (if we get them)

RHESSI

- Imaging & Spectral Analysis > 3keV
- Characteristics of accelerated and heated particles from non-thermal & thermal X-ray emission

- **Challenges: Degraded performance ‘06, ‘07 due to radiation damage, fixed Nov’07**
  - Higher than expected temperature
  - Higher background can hide non-thermal emission
• Some events where coronal energy release predominantly heating not acceleration
  – Bone et al. 2008 (ASPC 397)
  – Milligan 2007 (ApJL 680)
• Non-thermal loop emission not thin target
  – Krucker et al. 2007 (ApJL 671) [Sam’s talk at 11:00]
• Lack of Neupert Effect
  – McCaughey et al. (Poster P9-6)
  – Hannah et al. 2008 (A&A 481)
  • Next slide
• Hannah et al. 2008 (A&A 481)
  – Unusual microflare with hard spectrum to high >50 keV and possibly low 4 keV energies. Clear HXR footpoints matching XRT, TRACE & violation of Neupert Effect
New Observations

• Previous RHESSI & Hinode flare observations were not helped by RHESSI’s pre-anneal performance
  – This has made analysis difficult
  – Produced uncertainties in interpreting results
    • i.e. Could not determine low energy cut-off of accelerated electrons in Hannah et al. 2008 (A&A)

• New RHESSI & Hinode microflare observations post Nov’07
  – 3 events from AR10978, December 2007
    • 10-Dec-2007 07:00 GOES B7
    • 10-Dec-2007 08:10 GOES B4
    • 10-Dec-2007 11:36 GOES B3.5
  – Many microflares with good RHESSI coverage and sometimes multiple filter observations with Hinode/XRT from this AR
  – Work in Progress.......
Heating in nearby/flaring loop before impulsive phase?

XRT: C_poly/Open, 06:47:32 +0.18sec

RHESSI Lightcurve

XRT MOVIE
RHESSI Analysis of Event

- Detailed RHESSI Images and spectral fitting
  - Temperature and Emission Measure from spectral fit

XRT IMAGES
x,y shift to match RHESSI

RHESSI 4-8keV
RHESSI 12-20keV
Long Duration, gradual event, small amount of non-thermal

XRT: C_poly/Open, 07:49:12 +0.18sec

RHESSI Lightcurve

3-6 keV  6-12 keV  12-25 keV

XRT IMAGES
x,y shift to match RHESSI

RHESSI 4-8keV
RHESSI 12-20keV
• Impulsive HXR emission, multiple hot loops

XRT: C_poly/Open, 11:38:03 +0.26sec

RHESSI Lightcurve

3-6 keV  6-12 keV  12-25 keV

XRT IMAGES
x,y shift to match RHESSI

RHESSI 4-8keV
RHESSI 12-20keV
• RHESSI and Hinode observations provide interesting insights that challenge the standard flare model, i.e.
  – Why is the coronal energy release heating or acceleration dominated in some events

• Ideally need to do statistical survey of detailed SXR and HXR microflare properties
  – Easier post-anneal (Nov’07) but not many events
  – Many events pre-anneal but analysis challenges

• New opportunities with (hopefully) forthcoming events from Cycle 24 and new missions like SDO.